Stimulated retinal angle is not the only shape-related aspect of vision. Panel 2 of the National Television System Committee (NTSC) in 1940 set itself the following task as its question number 1: "Considering the shape and nature of the binocular visual field of view, can there be deduced any preferred aspect ratio for television pictures? Are there any other theoretical bases for the selection of any particular preferred aspect ratio?"[59]

The panel investigated various art forms and vision. In retinal isopters (intensity perception contours) an "aspect ratio" (a slight favoring of the horizontal versus the vertical) between 1:1 and 1.2:1 was found. In color fields, it was 1.3:1. Visual acuity offered the widest "aspect ratio" disparity, between 1.5:1 and 1.6:1 (a possible reason that the poor vertical resolution due to television's 2:1 interlace has not been as much of a problem as it might otherwise have been). An effect called the vertical-horizontal illusion was said to favor 1.1:1, and field of fixation (said to be related to eye movement) 1.2:1. No other vision-related differences that would suggest a bias for a particular aspect ratio were reported.

The NTSC also surveyed 31 existing television systems around the world. There were 1 with an 11:8 aspect ratio, 19 with 4:3, 7 with 5:4, 1 with 6:5, 2 with 3:4, and one with an unspecified aspect ratio.

A clear preference for a horizontally oriented aspect ratio was expressed: "Since most of man's activities occur in a horizontal plane, it is reasonable that there should be more freedom of motion horizontally than vertically." For aesthetic reasons, there were proponents on the NTSC of an aspect ratio of the Golden Section. That was considered too wasteful of the surface area of then-round picture tubes, however. To cope with the roundness problem, the committee set itself an aspect ratio limit of 1.4:1.

In the end, having found no compelling physiological or aesthetic reason to adopt a widescreen format, the NTSC selected a 4:3 aspect ratio and declared that the controlling factor was that it "has all advantages found in motion-picture practice." The other cited advantage was that it "permits motion-picture scanning without waste." It was a slightly curious choice, given that the motion-picture industry had changed to 11:8 (the Soviet TV aspect ratio investigated by the NTSC) a decade earlier.

The Eventual Advent of Widescreen

Today's problems of aspect ratio accommodation might be even worse had the NTSC met in 1929 instead of 1940. A technical paper published that year also tried to rationalize an aspect ratio for television and came to the same conclusion as did the NTSC -- that motion-picture practice should be the deciding factor. Since, at the time, sound tracks had eaten into the 4:3 frame, the selected aspect ratio was 6:5.[109]

By the time of the sound-track crisis, circa 1930, wide-aspect-ratio film technology was relatively advanced. All of the techniques that would later be used in the current widescreen era -- anamorphic squeezes and expansions, wider film, masked frames, multiple film strands -- had been demonstrated, sometimes used for theatrical release, and generally found to be technically successful.

Even before the Academy's standardization on an 11:8 (1.375:1) aspect ratio, however, the early era of wide film appeared to be going nowhere. The earliest wide aspect ratio systems (e.g., Eidoloscope) failed either because they were technically flawed or because the Motion Picture Patents Company dominated the industry.[2] As early as 1913, however, it was suggested to exhibitors in Britain to try masking 4:3 frames to create a wider aspect ratio. According to the article, "the result is a better shaped picture -- more artistic. The portion masked off will never be missed."[110] There does not appear to be any evidence of mass defections from 4:3 prior to the introduction of the sound track, however.

The Twenties saw a great deal of large-screen experimentation, each new form of which was supposed to herald a new era. Magnascope was simply an enlarging lens system. When dropped in front of an ordinary projection lens, it caused the picture to double linearly in size both horizontally and vertically (and become much dimmer), retaining a 4:3 aspect ratio or changing (through cropping) to whatever size the theater architecture would allow. It was said that it received a standing ovation when it was first used.[78]

The Fox Grandeur system was very much like today's 70 mm systems. Henri Chretien's Hypergonar anamorphic lens, used in production in 1927, is, in fact, the same lens that made CinemaScope possible (it had been used to create both wider and narrower aspect ratios, the latter by rotating the squeeze axis by 90 degrees).

The triptych presentation in Abel Gance's *Napoleon* (1927) was in some ways a precursor of Cinerama (though it wasn't used the same way). In 1929, SMPE's Standards Committee considered four large-frame widescreen systems ranging in film width from 35 mm (horizontal film travel, 10 perforations per frame) to 70 mm and in aspect ratio from 1.84:1 to 2.27:1[111] (as it has been recently suggested that 16:9 was developed as a linear compromise between the sound-track aperture and 2.35:1 and 1.85:1 as a compromise between 4:3 and 2.35:1,[112,113] it is worth noting that 1.85:1 was proposed as a preferred aspect ratio by two unrelated organizations long before the existence of 2.35:1).

An article called "Wide Film" in *The 1931 Film Daily Yearbook of Motion Pictures* summarized the situation succinctly: "Dormant condition of the subject is attributable to two major reasons. First, the fact that recent-year experiments failed to convince producers that enlarged pictures exercise a definite influence at the box office. Second, gigantic costs would be involved in changing the industry over to accommodate them."[114] There was an economic depression, and the industry had just begun to accommodate sound. Wide film, and wider aspect ratios, would have to wait.

After the NTSC's standardization of U.S. television (with a 4:3 aspect ratio) in 1941 and the end of World War II, the movie exhibition situation changed. Average weekly movie theater attendance in 1929, when SMPE's Standards Committee met to discuss wide film, was 95,000,000. In 1946, right after the war, it was 90,000,000, about the same as in 1930, despite a growing population. By 1953, however, it had dropped to just 46,000,000, a reduction generally attributed to television.[115] The movie industry decided to fight the audience loss by offering sensations that could not be experienced by watching television at home.[100]

"From an historical point of view both the so-called 3-D -- stereoscopic films -- and wide screen pictures are not new, dating back as they do to the earliest days of the art and industry. However, 3-D and wide screen pictures burst upon the American motion picture scene in the closing weeks of 1952 with all the suddenness of new-found comets. Each week, indeed, almost every day of 1953 was marked with an announcement of a new method, process or scheme."[51] One such process, "Scanoscope," applied CinemaScope's 2:1 anamorphic principles to television;[116] 3-D television was also broadcast at the time.[117]

It wasn't only 3-D and widescreen that exhibitors tried. The 19th-century Cineorama technique of completely encircling viewers with synchronized movie screens was revived at Disneyland in 1955. Cinerama and Todd-AO both used higher frame rates (26 and 30 fps, respectively). Those systems and others used deeply curved screens, sometimes extending into the seating area. During a rockslide sequence in *It Came From Outer Space* (1953), some theatrical viewers were pelted with foam rocks. Vibrators administered "shocks" to some seats when viewers watched *The Tingler* (1959), a technique recently revived in one of the motion-picture attractions at the Luxor Hotel in Las Vegas (the same theater's screen has a 0.5:1 or 1:2 aspect ratio). *Behind the Great Wall* (1959) was exhibited in Aromarama, featuring 72 different smells.[48]

None of these techniques was able to restore movie attendance to pre-1950 levels. In fact, it continued to fall, reaching a low of 15,800,000 in 1971. Nevertheless, wide aspect ratios, in at least some versions (cropping and anamorphic projection, neither of which was particularly expensive for an exhibitor to implement), endured, or, perhaps more precisely, thrived (more expensive processes, such as three-projector Cinerama and the multi-channel sound version of CinemaScope were less successful).

Recognizing a need for revenues beyond a limited market of specially equipped theaters, producers of movies in some of the new systems also shot the same scenes on ordinary 35 mm frames, thereby eliminating aspect-ratio (and, in some cases, frame-rate) accommodation problems. Producers of ordinary 35 mm movies, seeking to cash in on the attraction of widescreen, faced a different problem.

Shane (1953), composed and intended for viewing in a 1.375:1 aspect ratio, was projected instead at 1.66:1 when it was premiered at Radio City Music Hall, a ratio Paramount found tolerable as it involved cropping just 10% from the top and bottom of a 4:3 image (Paramount adamantly opposed projection at any ratio greater than 2:1, even for VistaVision movies, which were composed for wider aspect ratios[118]). *The Band Wagon* (1953) fared less well in cropped exhibition, with complaints received about the loss of the dancing feet of Fred Astaire and Cyd Charisse. Nevertheless cropping of existing movies became common practice. "The fact that many actors

found their heads chopped off and many dancers found that their feet were not on the screen didn't seem to bother the exhibitor or the theater patron to any degree. The public was fascinated with the wide screen."[51]

Distributors were very flexible about aspect ratio, lest they lose the business of some exhibitors. A Universal-International promotional document for *Imitation of Life* (1959) informs exhibitors "Aspect ratio: any ratio up to 2:1."

Acceptance of cropping continues to the present, regardless of the intended or displayed aspect ratios. The most commonly noticed form of cropping occurs when widescreen movies are shown on television screens via the truncation method. A scope movie converted to a flat print for theatrical projection at between 1.66:1 and 1.85:1 also undergoes cropping, however, even though no video is involved.[17] Ordinary 4:3 U.S. television coverage of the 1992 World Series baseball championship was shown on the 10:3 (3.33:1) Jumbotron screen of the Toronto Skydome to accommodate fans. Though the uncropped picture was available free of charge on broadcast television, viewers paid to watch the cropped version in the stadium (on a giant screen but one with a small visual angle due to its great distance from viewers).

Filmmakers' Acceptance of Widescreen

It is readily understandable why a filmmaker would not favor cropping. Even when cropping was not an issue, however, there were initial objections to wide aspect ratios among cinematographers and directors.

Cinematographer Fred Westerberg actively opposed ratios as wide as 2:1 during the sound-track aspect-ratio debates circa 1930. During the same debates, cinematographer Karl Struss, who favored 5:3, said 2:1 would result in smaller images and its lack of proportional height was problematic, and Joseph Dubray, described as a "motion picture engineer and erstwhile cameraman," said that the consensus in Hollywood was that 2:1 was "neither pretty nor desirable."[81]

More recently, cinematographer Lee Garmes said, "I found working in CinemaScope a horror -- shallow focus, very wide angles, everyone lining up, awful."[119] Other cinematographers in the same period had somewhat more forgiving comments. Walter Lassally: "I think 'scope is all right. I'm not mad about it personally, but it is suitable for certain subjects. It's very good for outdoor subjects, Westerns, scenes of epic proportions, but it's no good for intimate subjects." Paul Beeson: "I think if you've got a very small intimate subject it's crazy doing it in Panavision; you're just wasting the process. Panavision is really for a large canvas. When you're in close-up all the time it's very difficult to compose for Panavision. There's a lot of wasted space on either side, but these difficulties can be overcome if the director requires this format, although I don't think the subject gains anything."[40] Lucien Ballard: "I like 1.75, 1.8, almost the old screen ratio best."[120]

Director George Stevens was perhaps the most acerbic, referring to the CinemaScope aspect ratio as "a system of photography that pictures a boa constrictor to better advantage than a man." He also provided the adage that "no screen is larger than its smallest dimension."[107]

Director Stanley Kubrick released in 1994 a restored version of *Dr. Strangelove or: How I Learned to Stop Worrying and Love the Bomb* (1964). Film Forum in New York screened the release in "the squarish 1.66:1 ratio Kubrick originally intended, with more detail now visible at the top and bottom of the screen."[121] As recently as 1995, Lassally wrote, "The adoption of, say, 1.75:1 as a universal new standard... would in my opinion greatly benefit the industry as a whole."[122]

Except for those in the preceding paragraph, however, it has been roughly 25 years since the most recent of those sentiments was expressed, and, as the ASC's position on displays indicates, there has clearly been a shift of position. It was Stevens's *Shane* that had been cropped at the beginning of the current widescreen era; he went on to direct (and produce) the very wide aspect ratio (2.75:1) epic *The Greatest Story Ever Told* (1965).

Some of the unfavorable comments may be attributed simply to a change in traditional methods. In an article called "New Medium -- New Methods," Director Jean Negulesco wrote of his experiences with CinemaScope. "'Writing for the new wide screen should be easy,' I told my script writer 'All you have to do is put your paper in the typewriter sideways.' Well, he didn't laugh either."

Henry Koster, director of the first CinemaScope movie, *The Robe* (1953), said the process made "a director at last free of the camera" without having "to worry about 'dolly shots' and 'pan shots' and 'boom shots' and all other camera movements." Negulesco added that CinemaScope freed a director from concern about cuts, dissolves, closeups, and inserts.[52] Clearly, even such favorable comments have aged; today, scope cameras are dollied, panned, and boomed often, and the resulting shots are intercut, dissolved, and inserted; there are even widescreen closeups.

The Perfect Aspect Ratio

It is normal for opinions and techniques to change with time. Standardization of a particular display shape, however, especially when that shape is imposed upon a large glass bulb, locks in a specific preference well into the future. Therefore, it is worth very carefully considering any proposed display aspect ratio for ATV/HDTV.

IMAX was designed originally to allow nine 35 mm film images to appear simultaneously on a single screen,[123] and it retains its basic non-widescreen camera aperture[38] (its projector aperture has been variously specified, and its screens vary, too, but they are usually near 4:3 and are never even as wide as 1.66:1).[72] It is an extremely popular film format,[124] and has recently added feature-length and star-cast fictional/dramatic movies. Does this indicate a trend towards narrower aspect ratios in motion-picture film? Should such a trend be considered?

HDTV is said to have a need to be interoperable with other media. The most common computer picture tube display shape is 4:3, though such displays vary between 1:1 and 1.5:1 (and may be rotated 90 degrees to create aspect ratios less than 1:1). In print, the familiar U.S. 8.5- by 11-inch piece of paper has an aspect ratio of 0.77:1 or, rotated 90 degrees, 1.29:1; its international counterpart, the A4 size, is 210- by 297 mm, an aspect ratio of 0.71:1, or, rotated 90 degrees, 1.41:1 ($2^{1/2}$:1). In a book on the history of papermaking, there is no evidence of any aspect ratio of 2:1 or greater.[125] Photographic aspect ratios commonly used (ignoring vertical orientations) range from a minimum of 1:1 to a maximum of 1.5:1, except for rarer panoramic formats.[126]

Here is a list of some currently used or proposed aspect ratios for moving image media displays:

Infinite - This is one way to describe the cylindrical surround theaters such as those found at Disney amusement parks. It seems highly impractical for a home advanced television display.

48:9 (5.33:1) - This is the ratio of Toshiba's HD Horizon system, using three 16:9 projected HDTV images placed end to end. The first use of the system was documentation of the restored Michelangelo-painted ceiling of the Sistine Chapel.

4:1 - This ratio is commonly created when three 4:3 images are combined, as at the *Geographica* video theater in Washington, D.C. In the Tokyo Audio Visual Center Superwide-Vision system, the combination is internal to a video camera, so a single lens may be used.

10:3 (3.33:1) - This is the shape of the Jumbotron display at the Toronto Skydome.

2.75:1 to 2.55:1 - Some anamorphic film projection and most anamorphic video projection falls within this range, the latter because it is the result of applying a common 2:1 anamorphic expansion to television's 4:3 aspect ratio, resulting in 8:3 (2.67:1).

2.4:1 to 2.35:1 - This is the projection range most commonly recommended for 35 mm anamorphic movies. Theaters do not always abide by recommendations. If it is accepted that this is the widest commonly found aspect ratio, then a display of this shape offers the benefit of allowing masking for narrower images to be drawn in from the sides (like theatrical curtains), rather than from the sides, top, and bottom.

2.2:1 - This is the recommended shape of projected 70 mm movies; again, theaters do not always abide by recommendations.

2:1 - This is the display aspect ratio proposed by the ASC. A few widescreen movies were shot in this aspect ratio. For comparison purposes, it may be expressed as either 18:9 or 16:8 (2:1 is already an integer ratio).

1.85:1 - This is the projection aspect ratio most commonly recommended in the United States for non-anamorphic 35 mm widescreen movies.[19] There is less than 4% difference between this aspect ratio and 16:9 (there is a comparable difference between the original Academy aperture of 1.375:1 and 1.33:1).

1.8:1 - This ratio was selected by SMPE in 1930 on the basis on an AMPAS recommendation to be used with wide film. For its tests, SMPE used a 1.78:1 (16:9) screen. In the current edition of the *American Cinematographer Manual* (1993), 1.8:1 is listed as the aspect ratio of a proposed theatrical anamorphic projection system designed to replace the current 2.4:1.[38] There is much less difference between this ratio and 16:9 than between the Academy aperture of 1.37:1 and 1.33:1. There is also much less difference between 1.8:1 and 16:9 than between 2.4:1 and 2.35:1.

16:9 (1.78:1) - This is the aspect ratio of the standards SMPTE 240M and SMPTE 260M. It has also been adopted by other countries around the world for both HDTV and other forms of widescreen television.

1.75:1 - This is a popular projection aspect ratio in some theaters around the world. It was once called "the widest screen possible without changes in camera technique" [from that used for non-widescreen movies].[52]

1.66:1 (5:3) - This is a popular widescreen projection aspect ratio in many theaters outside the United States. Some HDTV programming has been shot in this aspect ratio.

14:9 (1.56:1) - This is a very common aspect ratio used to mitigate the effects of letterbox when HDTV is downconverted to non-HD TV.[127] It is so commonly desired that it exists as a preset function in some aspect ratio conversion equipment.[128]

16:10.7 (1.5:1) - This strangely enumerated ratio (an integer ratio of 3:2), also called Cinema Wide, is offered by Pioneer in projection television receivers.[129] Like 14:9, it is intended as a compromise ratio between HDTV and non-HD TV. The method of numbering the ratio appears intended to promote it as having even larger numbers than 16:9, lending some credence to a complaint about the promotional use of the 16:9 ratio relative to others in press releases.[22] As 1.5:1, this aspect ratio is also the shape of the VistaVision frame[38] and has been suggested as a shape for the future.[130]

1.375:1 (11:8) to 1.37:1 - This is the shape of almost all movies shot between 1933 and 1953 and many thereafter. It is sometimes described as being 4:3 or 1.33:1 even though it differs from that aspect ratio by 3.2%, almost as much as the difference between 1.85:1 and 16:9.

4:3 (1.33:1) - This is the shape of virtually all television programming and display screens, virtually all CRT-based computer display screens, and many movies. As the narrowest commonly used or recommended aspect ratio, it is the most efficient for the manufacture of cathode-ray tubes (1:1 would be even more efficient, if such displays were commonly used). It is the longest-lived aspect ratio for moving imagery and continues to be chosen for recent large-format film systems, such as the 70 mm IMAX and Dynavision systems.[38]

Narrower than 4:3 - This is the shape of some post-sound-track, pre-Academy-aperture movies, some computer display screens, and some special venue films. Data Check, a manufacturer of television monitoring equipment, in 1995 introduced tiny 1:1 picture-tube-based monitors on which even 4:3 images are displayed in a letterbox format.

Conclusions

This paper began with the statement that two aspect ratios are inherently incompatible and has ended with a list of well over a dozen different aspect ratios. The techniques of aspect ratio accommodation are equally applicable to any. There is no clear evidence of an aesthetic or physiological reason to choose any one aspect ratio over another.

For the particular ranges of aspect ratios between 4:3 and 2.35:1 (or between 1.15:1 and 2.75:1), a display shape of approximately 16:9 will require the least aspect ratio accommodation for both extremes of the range. For the specific requirement of doubling ITU-R Recommendation 601 (720 active picture elements per line) resolution for HDTV, 16:9 best matches random-access memory capacities.

If those characteristics and the others listed in this paper are considered insignificant or become outweighed by other considerations, there may no longer be a strong reason to choose 16:9. The 16:9 aspect ratio has already been chosen, however, and is in use around the world. The research for this paper has not found any compelling reason to change any existing choice of aspect ratio.

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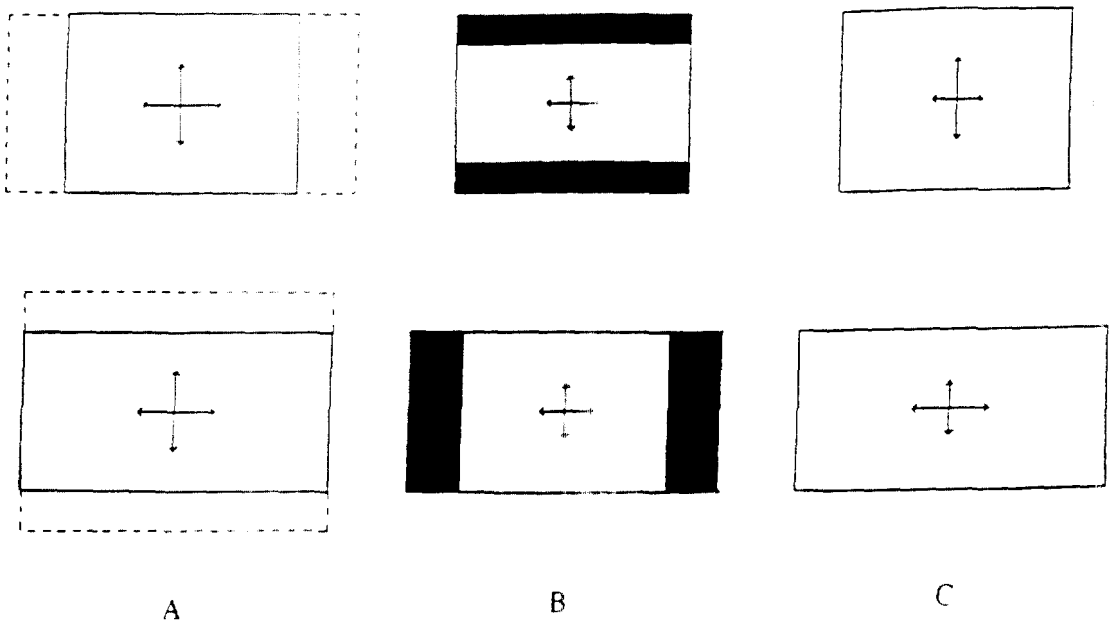


Figure 1 - Aspect Ratio Accommodation

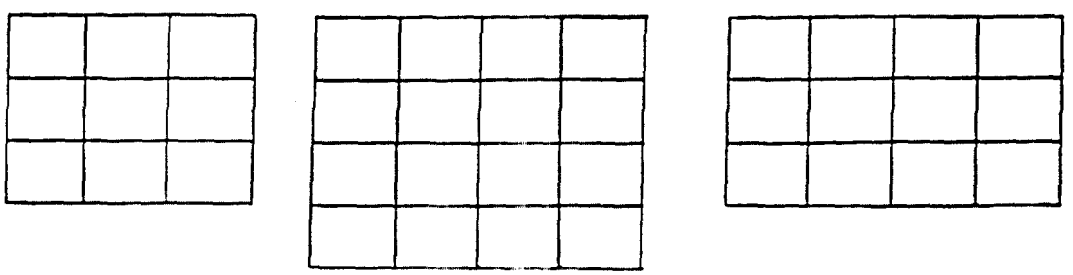
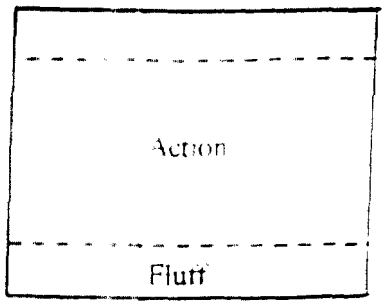


Figure 2 - Modular Display Configurations



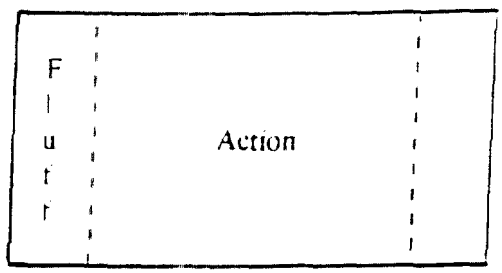


Figure 3 - Shoot & Protect

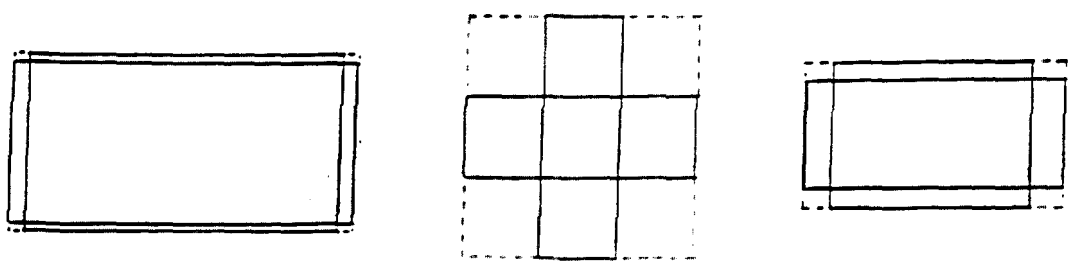


Figure 4 - Equal-Area Shoot & Protect

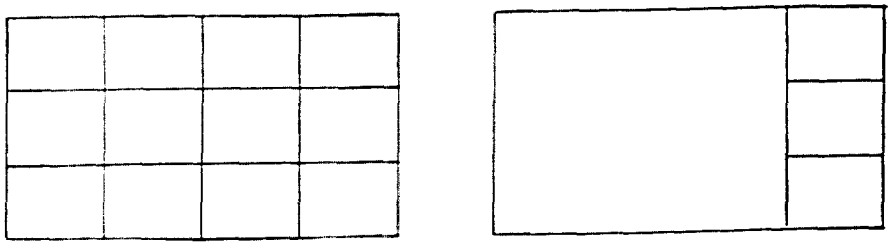


Figure 5 - 16:9 Alternative Display Modes

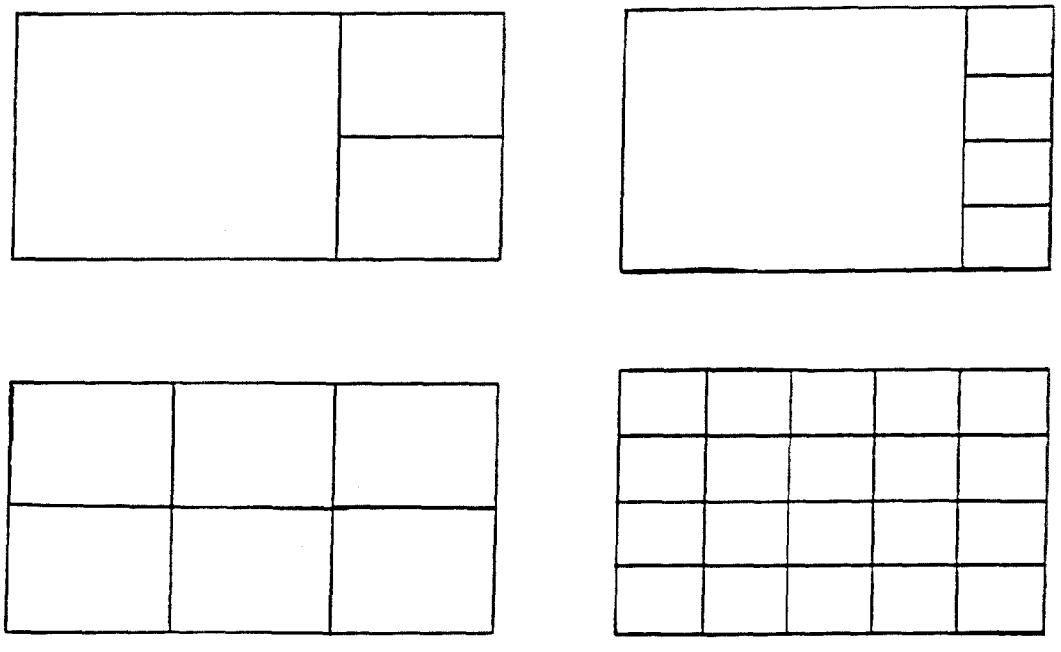


Figure 6 - Alternative MPIP and Polyscreen

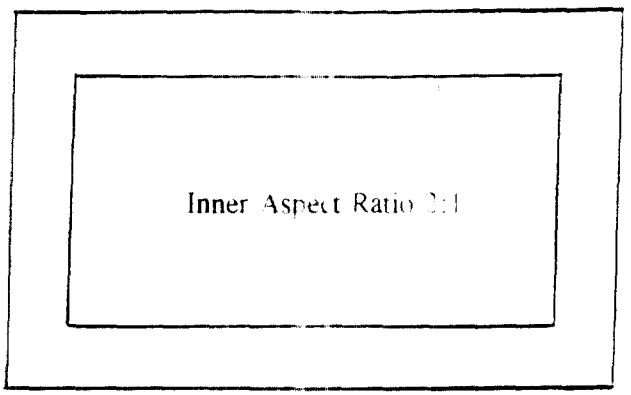


Figure 8 - Picture Frame Effect on Aspect Ratio

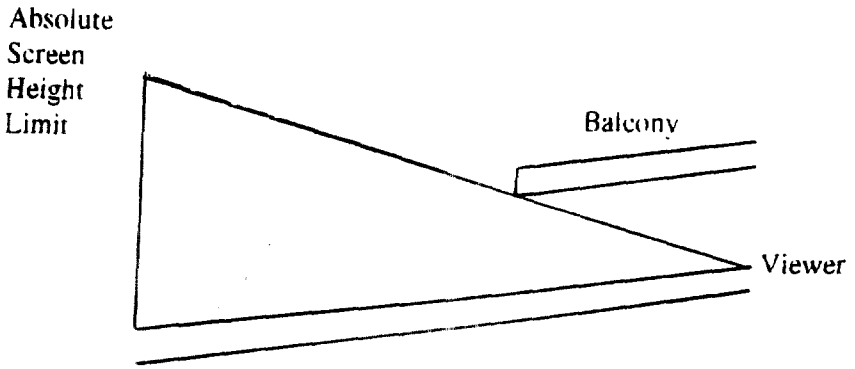


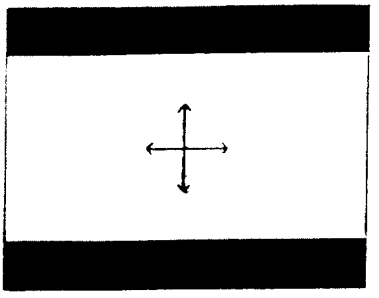
Figure 9 - Balcony Overhang Screen Height Limitation

Video Display Manufacturing Costs

Feature	Cost Basis
Deflection	Width
Screen	Area
Shadow mask	Area
Bulb	Volume = Area x depth (based on width)
Overall	Roughly Diagonal-based

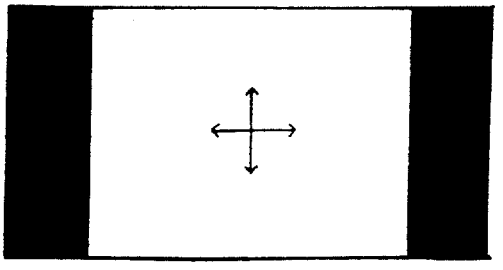
Image Sizes For Letterboxed Equal Diagonal Displays

Display					
4:3	100%	80%	72%	61%	56%
3:2	85%	87%	78%	66%	60%
5:3	73%	92%	83%	70%	64%
16:9	67%	83%	86%	72%	66%
2:1	55%	69%	77%	76%	69%
Image	1.33:1	1.66:1	1.85:1	2.2:1	2.4:1



Screen Area Left Blank Due To Shrunken Images And Loss Of Resolution For Fixed Display Scanning

	Horizontal	- resolution loss -			Vertical
Display					
4:3	0%	20%	28%	39%	44%
3:2	11%	10%	19%	32%	38%
5:3	20%	0%	10%	24%	31%
16:9	25%	7%	4%	19%	26%
2:1	34%	17%	8%	9%	17%
Image	1.33:1	1.66:1	1.85:1	2.2:1	2.4:1



Loss Of Resolution For Fixed Display Memories

Vertical						Horizontal					
					Display						
0%	20%	28%	39%	44%	4:3	18%	18%	18%	18%	18%	
6%	15%	24%	36%	41%	3:2	23%	13%	13%	13%	13%	
11%	11%	19%	32%	38%	5:3	27%	9%	9%	9%	9%	
13%	13%	17%	30%	36%	16:9	29%	12%	6%	6%	6%	
18%	18%	18%	26%	32%	2:1	34%	17%	8%	0%	0%	
1.33:1	1.66:1	1.85:1	2.2:1	2.4:1	Image	1.33:1	1.66:1	1.85:1	2.2:1	2.4:1	

The Top 100 Domestic Grossers of All Time

Variety, February 20 26, 1995, page A84

Compiled by Leonard Klady

With Aspect Ratio Added Based On

Leonard Maltin's 1996 Movie . Video Guide, Signet 1995

Gross represents U.S. domestic theatrical box office revenues
(not adjusted for inflation)
Aspect ratio represents shooting aspect ratio
(not necessarily projected aspect ratio)

Rank	Film	Gross	Aspect Ratio
1	E.T - The Extra Terrestrial	399,804,539	Not over 1.85
2	Jurassic Park	356,763,175	Not over 1.85
3	Star Wars	322,000,000	2.4
4	The Lion King	310,055,725	Not over 1.85
5	Forrest Gump	300,565,386	2.4
6	Home Alone	285,761,243	Not over 1.85
7	Return of the Jedi	263,000,000	2.4
8	Jaws	260,000,000	2.4
9	Batman	251,188,924	Not over 1.85
10	Raiders of the Lost Ark	242,374,454	2.4
11	Beverly Hills Cop	234,760,478	Not over 1.85
12	The Empire Strikes Back	222,674,266	2.4
13	Ghostbusters	220,855,498	2.4
14	Mrs. Doubtfire	219,195,051	2.4
15	Ghost	217,631,306	Not over 1.85
16	Aladdin	217,350,219	Not over 1.85
17	Back to the Future	208,242,016	Not over 1.85
18	Terminator 2	204,843,345	Unknown *
19	Indiana Jones...Last Crusade	197,171,806	2.4
20	Gone With The Wind	191,749,436	Not over 1.85
21	Dances With Wolves	184,208,848	2.4
22	The Fugitive	183,875,760	Not over 1.85
23	Indiana Jones...Temple...Doom	179,870,271	2.4
24	Pretty Woman	178,406,268	Not over 1.85
25	Tootsie	177,200,000	2.4
26	Top Gun	176,781,728	Unknown *
27	Snow White...Seven Dwarfs	175,263,233	Not over 1.85
28	Crocodile Dundee	174,634,806	2.4
29	Home Alone 2	173,585,516	Not over 1.85
30	Rain Man	172,825,435	Not over 1.85
31	Three Men and a Baby	167,780,960	Not over 1.85
32	Robin Hood: Prince of Thieves	165,493,908	Not over 1.85
33	The Exorcist	165,000,000	Not over 1.85
34	Batman Returns	162,831,698	Not over 1.85
35	The Sound of Music	160,476,331	2.2:1
36	The Firm	158,340,292	Not over 1.85
37	Fatal Attraction	156,645,693	Not over 1.85
38	The Sting	156,000,000	Not over 1.85
39	Who Framed Roger Rabbit?	154,112,492	Not over 1.85
40	Beverly Hills Cop 2	153,665,036	Unknown *
41	Grease	153,112,492	2.4
42	Rambo: First Blood 2	150,415,432	2.4
43	Gremlins	148,168,459	Not over 1.85
44	Lethal Weapon 3	147,253,986	2.4
45	True Lies	146,282,411	Unknown *
46	Beauty and the Beast	145,863,363	Not over 1.85
47	Lethal Weapon 2	144,731,527	2.4

48	101 Dalmations	43,992,148	Not over 1.85
49	The Santa Clause	42,711,007	Not over 1.85
50	Animal House	41,600,000	Not over 1.85
51	A Few Good Men	41,340,178	2.4
52	Look Who's Talking	40,088,813	Not over 1.85
53	Sister Act	39,605,150	Not over 1.85
54	Platoon	37,963,328	Not over 1.85
55	Teenage Mutant Ninja Turtles	35,265,915	Not over 1.85
56	Superman	34,218,018	2.4
57	The Rocky Horror Picture Show	34,198,189	Not over 1.85
58	The Godfather	33,698,921	Not over 1.85
59	Silence of the Lambs	30,726,716	Not over 1.85
60	Honey, I Shrunk the Kids	30,724,172	Not over 1.85
61	The Flintstones	30,528,634	Not over 1.85
62	An Officer and a Gentleman	29,795,549	Not over 1.85
63	The Jungle Book	28,647,178	Not over 1.85
64	Close Encounters...Third Kind	28,290,347	2.4
65	Coming to America	28,152,301	Not over 1.85
66	Rocky 4	27,873,414	Not over 1.85
67	Smokey and the Bandit	26,737,428	Not over 1.85
68	Sleepless in Seattle	26,670,704	Not over 1.85
69	Good Morning Vietnam	23,922,370	Not over 1.85
70	City Slickers	23,829,734	Not over 1.85
71	Rocky 3	22,823,192	Not over 1.85
72	Clear and Present Danger	22,010,252	2.4
73	The Bodyguard	21,945,720	Not over 1.85
74	Wayne's World	21,697,323	Unknown *
75	Speed	21,248,145	2.4
76	The Hunt for Red October	20,709,868	2.4
77	The Mask	19,913,630	Not over 1.85
78	Hook	19,654,823	2.4
79	Blazing Saddles	19,500,000	2.4
80	Total Recall	19,394,839	Not over 1.85
81	On Golden Pond	18,710,777	Not over 1.85
82	Back to the Future 2	18,450,002	Not over 1.85
83	Basic Instinct	17,727,224	2.4
84	Die Hard 2	17,323,878	2.4
85	Rocky	17,235,247	Not over 1.85
86	The Towering Inferno	16,000,000	2.4
87	Karate Kid 2	15,103,979	Not over 1.85
88	American Graffiti	15,000,000	2.4
89	Big	14,968,774	Not over 1.85
90	The Addams Family	13,502,246	Not over 1.85
91	Ghostbusters 2	12,494,738	2.4
92	One Flew Over...Cuckoo's Nest	12,000,000	Not over 1.85
93	Twins	11,936,388	Not over 1.85
94	Doctor Zhivago	11,721,913	2.4
95	Dumb and Dumber	11,609,826	Not over 1.85
96	Star Trek 4	09,713,132	2.4
97	Crocodile Dundee 2	09,306,210	2.4
98	Terms of Endearment	08,423,489	Not over 1.85
99	Superman 2	08,185,706	2.4
100	A League of Their Own	07,404,544	2.4

* These films were shot in a Super 35 format, which could have a variety of different aspect ratios.

Summary

	1.85 or less		Over 1.85		Unknown	
	Films	Gross	Films	Gross	Films	Gross
Top 5	3	$1,067M	2	623M	0	0
Top 10	5	1,604	5	1,388	0	0
Top 15	7	2,056	8	2,050	0	0
Top 20	10	2,673	9	2,248	1	205
Top 25	12	3,036	12	2,789	1	205
Top 30	15	3,557	13	2,964	2	382
Top 35	19	4,218	14	3,124	2	382
Top 40	23	4,843	14	3,124	3	535
Top 45	24	4,992	17	3,575	4	682
Top 50	28	5,566	18	3,720	4	682
Top 55	32	6,119	19	3,861	4	682
Top 60	36	6,648	20	3,995	4	682
Top 65	40	7,165	21	4,124	4	682
Top 70	45	7,794	21	4,124	4	682
Top 75	47	8,039	23	4,367	5	803
Top 80	49	8,278	26	4,727	5	803
Top 85	52	8,633	28	4,962	5	803
Top 90	55	8,976	30	5,193	5	803
Top 95	58	9,312	32	5,417	5	803
Top 100	59	9,420	36	5,852	5	803

Even if all the unknowns are added to the "Over 1.85" section, the "1.85 or less category still has the highest grosses.

The "1.85 or less" category also wins if global theatrical gross revenues are considered (*Variety*, February 13-19, 1995, page 28).

Worldwide 1994 Theatrical Gross Revenues

Variety, February 13 [illegible], 995, page 28

1994 Domestic Gross (1994 revenues only)

Rank	Film	Gross	Aspect Ratio
1	The Lion King	$298.9M	Not over 1.85
2	Forrest Gump	298.[illegible]	2.4
3	True Lies	146.[illegible]	Unknown *
4	The Santa Clause	134.[illegible]	Not over 1.85
5	The Flintstones	130.[illegible]	Not over 1.85
6	Clear & Present Danger	121.[illegible]	2.4
7	Speed	121.[illegible]	2.4
8	The Mask	118.[illegible]	Not over 1.85
9	Mrs. Doubtfire	107.4	2.4
10	Maverick	101.6	2.4
11	Interview...Vampire	100.[illegible]	Not over 1.85
12	The Client	92.[illegible]	2.4
13	Schindler's List	91.1	Not over 1.85
14	Philadelphia	76.[illegible]	Not over 1.85
15	Ace Ventura	72.[illegible]	Not over 1.85
16	Star Trek Generations	70.4	2.4
17	Stargate	68.[illegible]	2.4
18	Wolf	65.[illegible]	Not over 1.85
19	Pulp Fiction	62.4	2.4
20	Dumb & Dumber	59.[illegible]	Not over 1.85
21	Grumpy Old Men	57.[illegible]	Not over 1.85
22	The Specialist	55.8	Not over 1.85
23	4 Weddings And A Funeral	52.[illegible]	Not over 1.85
24	The Little Rascals	51.[illegible]	Not over 1.85
25	Naked Gun 33-1/3	51.[illegible]	Not over 1.85

In 1994, for the first time, foreign revenues for films tracked by *Variety* exceeded domestic revenues.

1994 Foreign Gross (1994 revenues only)

1	The Lion King	341.4	Not over 1.85
2	The Flintstones	211.0	Not over 1.85
3	Schindler's List	209.0	Not over 1.85
4	True Lies	208.1	Unknown *
5	Mrs. Doubtfire	202.6	2.4
6	4 Weddings...Funeral	190.2	Not over 1.85
7	Forrest Gump	182.8	2.4
8	Speed	161.6	2.4
9	Philadelphia	111.0	Not over 1.85
10	The Mask	93.7	Not over 1.85
11	The Pelican Brief	87.2	2.4
12	Cool Runnings	86.0	Not over 1.85
13	The Specialist	83.8	Not over 1.85
14	Maverick	79.0	2.4
15	A Perfect World	77.0	2.4
16	Naked Gun 33-1/3	71.3	Not over 1.85
17	Clear & Present Danger	66.5	2.4
18	Beverly Hills Cop 3	59.6	Not over 1.85
19	Free Willy	59.2	2.4
20	Sister Act 2	57.8	Not over 1.85
21	The Three Musketeers	55.3	2.4
22	When A Man Loves A Woman	54.[illegible]	Not over 1.85

23	Demolition Man	52.9	2.4
24	The Client	51.8	2.4
25	Addams Family Values	44.2	Not over 1.85

* Film shot in Super 35.

Summary

	1994 Domestic			1994 Foreign		
Top	< or = 1.85:1	Over 1.85:1	???	< or = 1.85:1	Over 1.85:1	???
5	564	298	146	761	203	208
10	683	750	146	1,156	547	208
15	1,023	842	146	1,328	790	208
20	1,147	1,043	146	1,515	916	208
25	1,416	1,043	146	1,611	1,076	208

When only the top 10 films of 1994 are considered, those over 1.85:1 outgrossed those of 1.85:1 or under in domestic markets. At every other level (and in foreign markets), films of 1.85:1 or under outgrossed films with wider aspect ratios.

The History of the Perfect Aspect Ratio - Mark Schubin, Consultant

Extra-special thanks to the George Eastman House Library

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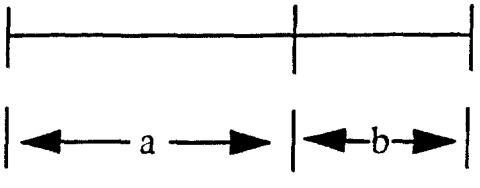
1. Is There A Single Perfect Aspect Ratio Based On
   - Compositional Preference?
   - Psychological Preference?
   - Physiological Characteristics?
   - Economic Considerations?

2. If Not, What Is To Be Done?

Compositional Preference

1994 ASC statement - 2:1 displays
1995 ASC member - 1.75:1
1971 ASC member - 1.75:1, 1.8:1
1930 ASC members - 1.62:1, 1.67:1, not 2:1
1995 moving image programming - 0.5:1 through infinite
(commonly 1.33:1, 1.66:1, 1.85:1, 2.2:1, 2.4:1)

Psychological Preference - The Golden Section



$$\frac{a}{b} = \frac{a+b}{a} = 1.618$$

Tabelle über die Versuche mit 10 Rechtecken.

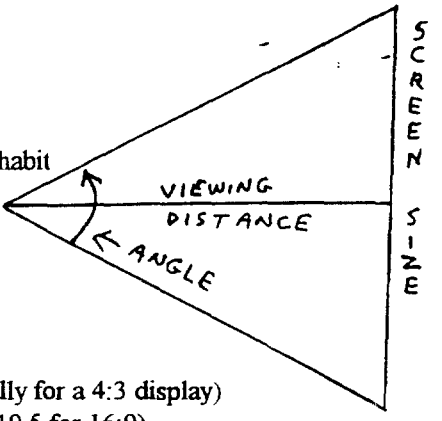
(V Seitenverhältniss, Z Zahl der Vorzugsurtheile, z Zahl der Verwerfungsurtheile, m. männlich, w. weiblich.)

V	Z		z		procent Z	
	m.	w.	m.	w.	m.	w.
1 □	6,25	4,0	36,67	31,5	2,74	3,36
	0,5	0,33	23,8	19,5	0,22	0,27
	7,0	0,0	14,5	8,5	3,07	0,00
	4,5	4,0	5,0	1,0	4,97	3,36
	13,33	13,5	2,0	1,0	5,85	11,35
	50,91	20,5	1,0	0,0	22,33	17,22
○	78,66	42,65	0,0	0,0	34,50	35,83
	49,33	20,21	1,0	1,0	21,64	16,99
	14,25	11,83	3,83	2,25	6,25	9,94
	3,25	2,0	57,21	30,23	1,48	1,68
Summa	228	119	150	95	100,00	100,00

Psychological Preference - Moving Images

Hummel formats seminars
- largest (not necessarily widest) format wins

Glenn/Philips
- slight dependence on angle
  - 4:3 for TV
  -5:3 for HD (30 degrees H)
- slight dependence on compositional intention and viewer habit



Pitts & Hurst/Sarnoff
- no dependence on angle
  - size makes no difference
  - distance data are contradictory

Ardito & Gunetti/RAI
- preferred viewing distances
  - 12" - ~8H (7.2 degrees vertically, 9.5 horizontally for a 4:3 display)
  - 38" - 5.2H (11 degrees vertically, 18.3 for 5:3, 19.5 for 16:9)
  - 160" - ~3H (18.9 degrees vertically, 37.9 for 2:1)
  (HDTV is supposed to be ~ 3H)

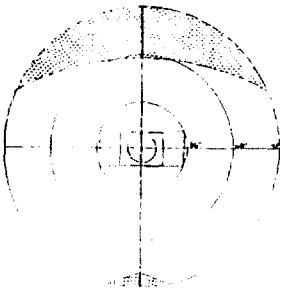
Voting With A Wallet

1994 ASC - 2:1 Displays
1995 *Variety*
- All-time highest grossers: *E.T.*, *Jurassic Park*
- Top 100 grossers: 1.85:1 or less wins by a 2:1 margin
- #5 *Forrest Gump*: shot 2.4:1, shown ?

1994 - Year-End Highest U.S. Single-Screen Theatrical Gross Per Seat - *Into The Deep*
1993 U.S. TV Ad Revenues - $30.6 billion
1993 U.S. Home Video Rentals and Purchases - $15 billion
Plus cable TV & satellite

Baywatch is viewed all over the world

Physiological Characteristics



Maximum Visual Field
- Glenn - 2:1
- Hatada, et. al - 1.6:1
- Szabo - 1.57:1 monocular
  - 1.03:1 binocular

Economic Considerations

Most efficient CRTs are round
For 90 degree corners, most efficient CRTs are square
Theater architectures require screens that fit

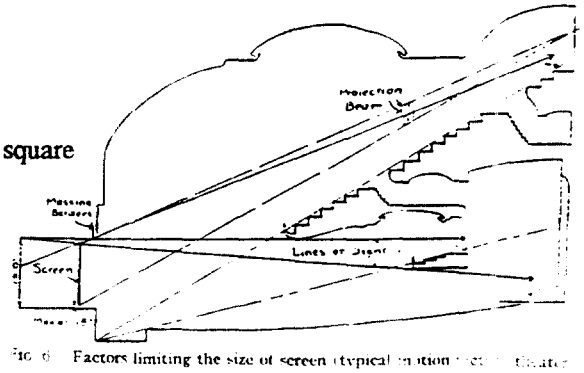
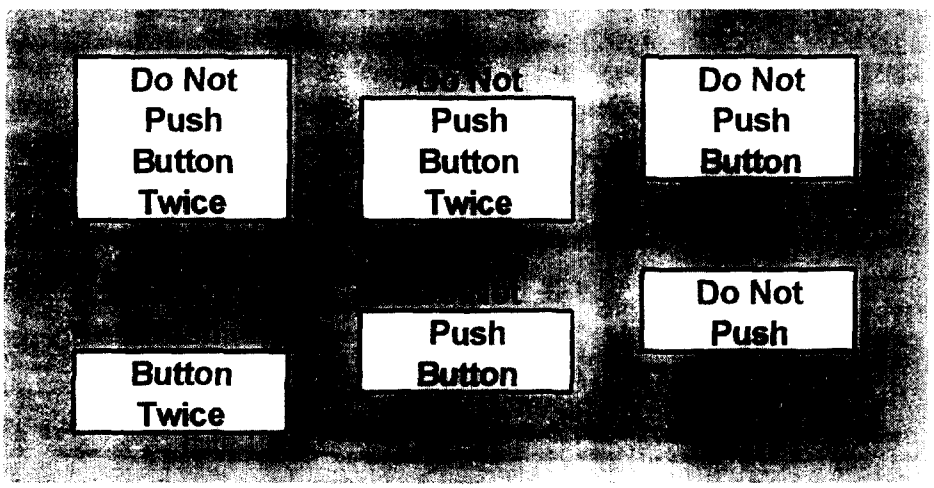


Fig. 6 Factors limiting the size of screen (typical situation [illegible] theater

History of 4:3

Date	4:3 System	Why
Pre-Cinema	3-4-5 right triangle	Repeatable with a loop
1889	Edison/Dickson kinetoscope	Anschutz? Aesthetics? 3-4-5?
1895	Lumiere shifts from 5:4	Edison (but not 4-perf)?
1896	Demeny-Gaumont 60 mm film	3-4-5? Aesthetics? Edison?
1898	Lumiere 75 mm film	Habit?
c. 1907-1914	The trust busters	Compatibility with the trust?
1925	Magnascope	Compatibility with the frames?
c. 1927-1932	Theaters with sound prints	Aesthetics?
1932	Academy aperture	Aesthetics? Existing screens?
1937	British TV	Movie compatibility?
1941	First NTSC	Movie compatibility (but not 11:8?)
1953	Second NTSC	Monochrome compatibility
1970	IMAX	Nine 35 mm frames at once
1986	FuturVision	Large screen impact

Any Two Aspect Ratios Are Inherently Incompatible!



Do Not
Push
Button
Twice

Do Not
Push
Button
Twice

Do Not Push Button Twice

Movie studio executive - 6% acceptable HDTV engineer - 4% Computer scientist - 2%

Dual Aspect-Ratio Transmission

16:9 image enters memory at $4f_{sc}$ and is read out at the same rate for a 16:9 image or $3f_{sc}$ for 4:3

The Shoot & Protect Paradox

If a 16:9 camera and display have identical scanning characteristics (e.g. 1080 active scanning lines), then a 4:3 display or a 2.35:1 screen will have 25% "fluff," but a 16:9 display will have 43%. Only if the display has different (and appropriate) scanning characteristics will the "fluff" be reduced to zero

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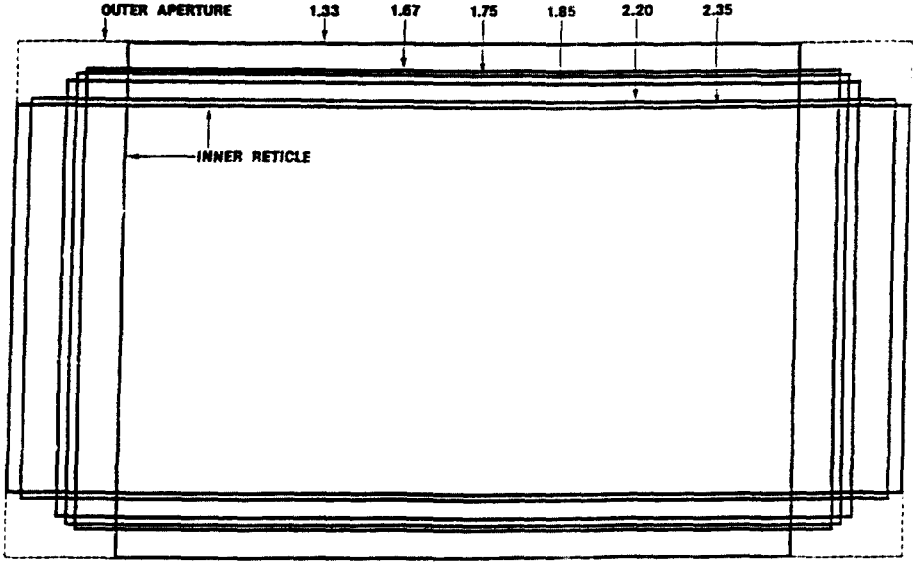
	Other Problems	Broadcast TV
It Came From Outer Space (1953)	Thrown foam rocks and 3-D	Editing for content
Dial M for Murder (1954)	3-D	Editing for time
Oklahoma! (1955)	30 fps	Commercial breaks
The Tingler (1959)	Buzzer seats	Speed changes
Behind The Great Wall (1959)	Aromarama	Resolution loss
Eyes of Hell (The Mask) (1961)	Color separation glasses	No gathered audience
How The West Was Won (1962)	Deeply curved screen	Limited color palette
Earthquake (1974)	Sensurround	Small screen size
Titanica (1992)	IMAX resolution	Bright room/limited contrast

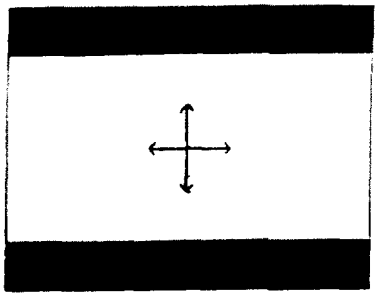


Video Display Manufacturing Costs

Feature	Cost Basis
Deflection	Width
Screen	Area
Shadow mask	Area
Bulb	Volume = Area x depth (based on width)
Overall	Roughly Diagonal-based

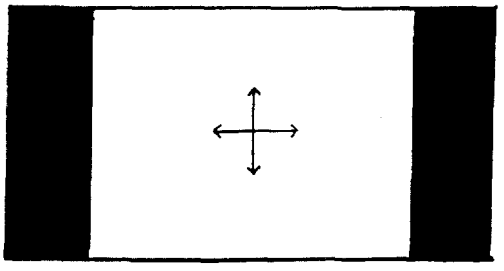
Image Sizes For Letterboxed Equal Diagonal Displays

Display					
4:3	100%	80%	72%	61%	56%
3:2	85%	87%	78%	66%	60%
5:3	73%	92%	83%	70%	64%
16:9	67%	83%	86%	72%	66%
2:1	55%	69%	77%	76%	69%
Image	1.33:1	1.66:1	1.85:1	2.2:1	2.4:1



Screen Area Left Blank Due To Shrunken Images And Loss Of Resolution For Fixed Display Scanning

Display	Horizontal - resolution loss -				Vertical
4:3	0%	20%	28%	39%	44%
3:2	11%	10%	19%	32%	38%
5:3	20%	0%	10%	24%	31%
16:9	25%	7%	4%	19%	26%
2:1	34%	17%	8%	9%	17%
Image	1.33:1	1.66:1	1.85:1	2.2:1	2.4:1



Loss Of Resolution For Fixed Display Memories

Vertical					Display	Horizontal				
0%	20%	28%	39%	44%	4:3	18%	18%	18%	18%	18%
6%	15%	24%	36%	41%	3:2	23%	13%	13%	13%	13%
11%	11%	19%	32%	38%	5:3	27%	9%	9%	9%	9%
13%	13%	17%	30%	36%	16:9	29%	12%	6%	6%	6%
18%	18%	18%	26%	32%	2:1	34%	17%	8%	0%	0%
1.33:1	1.66:1	1.85:1	2.2:1	2.4:1	Image	1.33:1	1.66:1	1.85:1	2.2:1	2.4:1

Selection Of An Aspect Ratio

Narrower	16:9	Wider
Bigger Screens	Global Acceptance	Better Wider
Better Narrower	Matches 3-Perf	Masking?
More V Rez	Closest to 1.85	More H Rez
Huge 4:3 Base	Matches Memory (IF)	
	Moderate Base	
	Best Accommodation of Extremes	
	Dual Composite TX	
	History (1930, 1953, 1.75)	
	Math Tricks (incl. MPIP & $4/3^3$)	
	1.5 Anamorphic	
	Between 1.66 & 1.85	

For Further Comments Or Questions

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